

WHAT IS CLAIMED IS:

1. A diffraction element comprising:  
a light-transmittable member; and  
a diffraction grating which is formed on at least one face of the light-transmittable member;

wherein when a first laser beam having a first wavelength  $\lambda_1$  and a second laser beam having a second wavelength  $\lambda_2$  are transmitted through the diffraction element, the first and second laser beams are turned into first and second diffracted beams having first and second diffraction efficiencies, respectively;

wherein the diffraction element functions to equalize the first and second diffraction efficiencies to each other by only the one face of the diffraction element;

wherein the diffraction grating has a first phase modulation amount  $\phi_1$  for the first laser beam and a second phase modulation amount  $\phi_2$  for the second laser beam and the first and second phase modulation amounts  $\phi_1$  and  $\phi_2$  are, respectively, approximately expressed by the following equations (1) and (2):

$$\phi_1 = 2\pi N_1 \pm \Delta\phi \text{ ---(1)}$$

$$\phi_2 = 2\pi N_2 \pm \Delta\phi \text{ ---(2)}$$

in which "N1" and "N2" are natural numbers and " $\Delta\phi$ " is a phase variation amount.

2. The diffraction element as claimed in Claim 1, wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$  so as to assume a value other than 0.5.

3. The diffraction element as claimed in Claim 1, wherein the first laser beam is a blue laser beam having a wavelength of 380 to 420 nm as the first wavelength  $\lambda_1$  and the second laser beam is a red laser beam having a wavelength of 630 to 680 nm as the second wavelength  $\lambda_2$ .

4. The diffraction element as claimed in Claim 1, wherein a depth  $h$  of the diffraction grating is approximately expressed by the following equation (3):

$$h = [N\lambda_1\lambda_2 / \{\lambda_1(n_2 - 1) + \lambda_2(n_1 - 1)\}] \text{ --- (3)}$$

in which "N" is a natural number, "n1" is a refractive index of the diffraction element for the first laser beam and "n2" is a refractive index of the diffraction element for the second laser beam;

wherein a zero-order diffraction efficiency of the first laser beam and that of the second laser beam are approximate to each other and a first-order diffraction efficiency of the first laser beam and that of the second laser beam are approximate to each other.

5. The diffraction element as claimed in Claim 4, wherein a depth  $h_1$  of the diffraction grating is expressed by the following equation (4):

$$h_1 = [\lambda_1\lambda_2 / \{\lambda_1(n_2 - 1) + \lambda_2(n_1 - 1)\}] \text{ --- (4)}$$

in which the natural number N is set to 1 in the equation (3).

6. The diffraction element as claimed in Claim 5, wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a / (W_a + W_b)\}$ ;

wherein when the duty ratio is 0.135, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

7. The diffraction element as claimed in Claim 4, wherein a depth  $h_2$  of

the diffraction grating is expressed by the following equation (5):

$$h_2 = [2\lambda_1\lambda_2 / \{\lambda_1(n_2-1) + \lambda_2(n_1-1)\}] \text{ ---(5)}$$

in which the natural number N is set to 2 in the equation (3).

8. The diffraction element as claimed in Claim 7, wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$ ;

wherein when the duty ratio is 0.2, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

9. The diffraction element as claimed in Claim 4, wherein a depth  $h_3$  of the diffraction grating is expressed by the following equation (6):

$$h_3 = [3\lambda_1\lambda_2 / \{\lambda_1(n_2-1) + \lambda_2(n_1-1)\}] \text{ ---(6)}$$

in which the natural number N is set to 3 in the equation (3).

10. The diffraction element as claimed in Claim 9, wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$ ;

wherein when the duty ratio is 0.5, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

11. The diffraction element as claimed in Claim 1, wherein the diffraction grating is formed by material having polarization anisotropy.

12. The diffraction element as claimed in Claim 1, wherein the diffraction grating is formed by isotropic material having no polarization anisotropy.

13. A method of designing a diffraction grating formed on only one face of a light-transmittable member in a diffraction element such that a first laser beam

having a first wavelength  $\lambda_1$  and a second laser beam having a second wavelength  $\lambda_2$  are transmitted through the diffraction grating at first and second diffraction efficiencies, respectively;

wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  and a depth  $h$  are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$  such that the first and second diffraction efficiencies are adjusted by using the duty ratio and the depth  $h$  of the diffraction grating as parameters.

14. The method as claimed in Claim 13, wherein the first laser beam is a blue laser beam having a wavelength of 380 to 420 nm as the first wavelength  $\lambda_1$  and the second laser beam is a red laser beam having a wavelength of 630 to 680 nm as the second wavelength  $\lambda_2$ .

15. The method as claimed in Claim 13, wherein the depth  $h$  of the diffraction grating is approximately expressed by the following equation (7):

$$h = [N\lambda_1\lambda_2 / \{\lambda_1(n_2 - 1) + \lambda_2(n_1 - 1)\}] \text{ --- (7)}$$

in which "N" is a natural number, "n1" is a refractive index of the diffraction element for the first laser beam and "n2" is a refractive index of the diffraction element for the second laser beam;

wherein a zero-order diffraction efficiency of the first laser beam and that of the second laser beam are approximate to each other and a first-order diffraction efficiency of the first laser beam and that of the second laser beam are approximate to each other.

16. The method as claimed in Claim 15, wherein a depth  $h_1$  of the diffraction grating is expressed by the following equation (8):

$$h_1 = [\lambda_1\lambda_2 / \{\lambda_1(n_2 - 1) + \lambda_2(n_1 - 1)\}] \text{ --- (8)}$$

in which the natural number N is set to 1 in the equation (7).

17. The method as claimed in Claim 16, wherein when the duty ratio is 0.135, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

18. The method as claimed in Claim 15, wherein a depth  $h_2$  of the diffraction grating is expressed by the following equation (9):

$$h_2 = [2\lambda_1\lambda_2 / \{\lambda_1(n_2-1) + \lambda_2(n_1-1)\}] \text{ ---(9)}$$

in which the natural number N is set to 2 in the equation (7).

19. The method as claimed in Claim 18, wherein when the duty ratio is 0.2, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

20. The method as claimed in Claim 15, wherein a depth  $h_3$  of the diffraction grating is expressed by the following equation (10):

$$h_3 = [3\lambda_1\lambda_2 / \{\lambda_1(n_2-1) + \lambda_2(n_1-1)\}] \text{ ---(10)}$$

in which the natural number N is set to 3 in the equation (7).

21. The method as claimed in Claim 20, wherein when the duty ratio is 0.5, a ratio of the zero-order diffraction efficiency to the first-order diffraction efficiency is approximate to (10/1).

22. An optical head device comprising:

a first laser beam source for emitting a blue laser beam having a first wavelength  $\lambda_1$ ;

a second laser beam source for emitting a red laser beam having a second wavelength  $\lambda_2$ ;

an optical lens for condensing at a minute spot on an information recording face of an optical information medium the blue laser beam or the red laser

beam;

a photodetector for outputting, in response to the blue laser beam or the red laser beam reflected on the information recording face of the optical information medium, an electric signal corresponding to a quantity of the blue laser beam or the red laser beam; and

a diffraction element including a light-transmittable member and a diffraction grating formed on at least one face of the light-transmittable member;

wherein when the blue laser beam and the red laser beam are transmitted through the diffraction element, the blue laser beam and the red laser beam are turned into first and second diffracted beams having first and second diffraction efficiencies, respectively;

wherein the diffraction element functions to equalize the first and second diffraction efficiencies to each other by only the one face of the diffraction element;

wherein the diffraction grating has a first phase modulation amount  $\phi_1$  for the blue laser beam and a second phase modulation amount  $\phi_2$  for the red laser beam and the first and second phase modulation amounts  $\phi_1$  and  $\phi_2$  are, respectively, approximately expressed by the following equations (11) and (12):

$$\phi_1 = 2\pi N_1 \pm \Delta\phi \quad \text{---(11)}$$

$$\phi_2 = 2\pi N_2 \pm \Delta\phi \quad \text{---(12)}$$

in which "N1" and "N2" are natural numbers and " $\Delta\phi$ " is a phase variation amount;

wherein the diffraction element generates a diffracted beam from the blue laser beam or the red laser beam and the photodetector receives the refracted beam so as to detect a servo signal.

23. An optical head device comprising:

- a first laser beam source for emitting a blue laser beam having a first wavelength  $\lambda_1$ ;
- a second laser beam source for emitting a red laser beam having a second wavelength  $\lambda_2$ ;
- an optical lens for condensing at a minute spot on an information recording face of an optical information medium the blue laser beam or the red laser beam;
- a photodetector for outputting, in response to the blue laser beam or the red laser beam reflected on the information recording face of the optical information medium, an electric signal corresponding to a quantity of the blue laser beam or the red laser beam; and
- a diffraction element including a light-transmittable member and a diffraction grating formed on at least one face of the light-transmittable member such that the blue laser beam and the red laser beam are transmitted through the diffraction grating at first and second diffraction efficiencies, respectively;

wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  and a depth are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$  such that the first and second diffraction efficiencies are adjusted by using the duty ratio and the depth as parameters;

wherein the diffraction element generates a diffracted beam from the blue laser beam or the red laser beam and the photodetector receives the refracted beam so as to detect a servo signal.

24. An optical information apparatus comprising:

an optical head device which includes a first laser beam source for emitting a blue laser beam having a first wavelength  $\lambda_1$ , a second laser beam source for emitting a red laser beam having a second wavelength  $\lambda_2$ , an optical lens for condensing at a minute spot on an information recording face of an optical information medium the blue laser beam or the red laser beam, a photodetector for outputting, in response to the blue laser beam or the red laser beam reflected on the information recording face of the optical information medium, an electric signal corresponding to a quantity of the blue laser beam or the red laser beam and a diffraction element having a light-transmittable member and a diffraction grating formed on at least one face of the light-transmittable member;

wherein when the blue laser beam and the red laser beam are transmitted through the diffraction element, the blue laser beam and the red laser beam are turned into first and second diffracted beams having first and second diffraction efficiencies, respectively;

wherein the diffraction element functions to equalize the first and second diffraction efficiencies to each other by only the one face of the diffraction element;

wherein the diffraction grating has a first phase modulation amount  $\phi_1$  for the blue laser beam and a second phase modulation amount  $\phi_2$  for the red laser beam and the first and second phase modulation amounts  $\phi_1$  and  $\phi_2$  are, respectively, approximately expressed by the following equations (11) and (12):

$$\phi_1 = 2\pi N_1 \pm \Delta\phi \quad \text{---(11)}$$

$$\phi_2 = 2\pi N_2 \pm \Delta\phi \quad \text{---(12)}$$

in which "N1" and "N2" are natural numbers and " $\Delta\phi$ " is a phase variation amount;



wherein the diffraction element generates a diffracted beam from the blue laser beam or the red laser beam and the photodetector receives the refracted beam so as to detect a servo signal;

a motor for rotating the optical information medium; and

an electric circuit for controlling and driving, on the basis of a signal received from the optical head device, the motor or one of the optical lens, the first laser beam source and the second laser beam source of the optical head device.

25. An optical information apparatus comprising:

an optical head device including a first laser beam source for emitting a blue laser beam having a first wavelength  $\lambda_1$ , a second laser beam source for emitting a red laser beam having a second wavelength  $\lambda_2$ , an optical lens for condensing at a minute spot on an information recording face of an optical information medium the blue laser beam or the red laser beam, a photodetector for outputting, in response to the blue laser beam or the red laser beam reflected on the information recording face of the optical information medium, an electric signal corresponding to a quantity of the blue laser beam or the red laser beam and a diffraction element having a light-transmittable member and a diffraction grating formed on at least one face of the light-transmittable member such that the blue laser beam and the red laser beam are transmitted through the diffraction grating at first and second diffraction efficiencies, respectively;

wherein land portions each having a width  $W_a$  and groove portions each having a width  $W_b$  and a depth are alternately arranged in the diffraction grating and a duty ratio is defined as  $\{W_a/(W_a+W_b)\}$  such that the first and second diffraction efficiencies are adjusted by using the duty ratio and the depth as parameters;

wherein the diffraction element generates a diffracted beam from the blue laser beam or the red laser beam and the photodetector receives the refracted beam so as to detect a servo signal;

a motor for rotating the optical information medium; and

an electric circuit for controlling and driving, on the basis of a signal received from the optical head device, the motor or one of the optical lens, the first laser beam source and the second laser beam source of the optical head device.

26. A computer comprising:

an optical information apparatus of Claim 24;

an input unit for inputting information;

an arithmetic unit for performing arithmetic operation on the basis of the information inputted by the input unit or information reproduced from the optical information apparatus; and

an output unit for displaying or outputting the information inputted by the input unit, the information reproduced from the optical information apparatus or a result of the arithmetic operation of the arithmetic unit.

27. A computer comprising:

an optical information apparatus of Claim 25;

an input unit for inputting information;

an arithmetic unit for performing arithmetic operation on the basis of the information inputted by the input unit or information reproduced from the optical information apparatus; and

an output unit for displaying or outputting the information inputted by the input unit, the information reproduced from the optical information apparatus or a result of the arithmetic operation of the arithmetic unit.

28. An optical information medium player comprising:  
an optical information apparatus of Claim 24; and  
a decoder for converting into an image an information signal obtained from the optical information apparatus.
29. An optical information medium player comprising:  
an optical information apparatus of Claim 25; and  
a decoder for converting into an image an information signal obtained from the optical information apparatus.
30. A car navigation system comprising:  
an optical information apparatus of Claim 24; and  
a decoder for converting into an image an information signal obtained from the optical information apparatus.
31. A car navigation system comprising:  
an optical information apparatus of Claim 25; and  
a decoder for converting into an image an information signal obtained from the optical information apparatus.
32. An optical information medium recorder comprising:  
an optical information apparatus of Claim 24; and  
an encoder for converting image information into information to be recorded on the optical information medium by the optical information apparatus.
33. An optical information medium recorder comprising:  
an optical information apparatus of Claim 25; and  
an encoder for converting image information into information to be recorded on the optical information medium by the optical information apparatus.
34. An optical disc server comprising:

an optical information apparatus of Claim 24; and  
an input/output terminal for exchanging information with an external  
appliance.

35. An optical disc server comprising:  
an optical information apparatus of Claim 25; and  
an input/output terminal for exchanging information with an external  
appliance.